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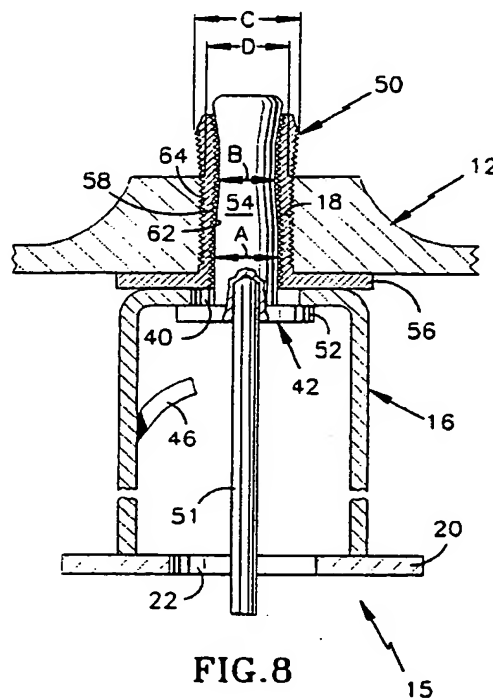
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(54) **Easily replaceable hot conduit liner**

(57) A serviceable liner is provided comprising an outer wall (12), an inner wall (10), a plurality of standoffs (16) disposed between the walls (10, 12), and a plurality of attachment assemblies (15) for attaching the walls to one another. The outer wall (12) includes a plurality of first apertures (18). The inner wall (10) includes a plurality of sections (20), each section (20) having at least one second aperture (22). Each attachment assembly includes a fastener (42) and an insert (50). An insert (50) is received within each first aperture (18) and a fastener (42) is received within each insert (50).



**FIG. 8**

**EP 0 778 408 A2**

## Description

This invention pertains to gas turbine engines in general, and in particular to liners within gas turbine engines.

Liners are often employed in gas turbine engines to enclose high temperature core gas paths. An augmentor, for example, may use a cylindrical or similarly shaped liner to direct core gas flow between the turbine exhaust and the nozzle. Liners generally include an outer wall (also called a "duct wall"), an inner wall (also called a "liner wall") and a means for spacing the two walls a distance apart. The duct created between the two walls is used as a cooling air passage. In conventional gas turbine engines, corrugations extending between the two walls space the two walls a distance apart. Fasteners attach the corrugations and the walls together and collectively form a rigid cylindrical structure. In most cases, access to the outside of the outer wall is necessary to attach the fasteners.

A significant pressure difference across the liner is necessary to force the cooling air through the liner. As a result, the liner experiences loadings similar to that of a pressure vessel. During operation of the engine, for example, the difference in pressure between the cooling gas within the duct and the core gas radially inside of the wall is such that the inner wall is forced inward around the entire circumference of the liner. If the inward force is too great for the inner wall, the wall can buckle and necessitate replacement. To avoid undesirable buckling, it is known to increase wall thicknesses within the liner, or add structural supports. Increasing the robustness of the walls and/or adding structural members can solve structural problems, but generally does so at the cost of adding undesirable weight.

High core gas temperatures can also limit the useful life of the augmentor liner. Cooling schemes and coatings can be used to decrease the rate of thermal damage, but eventually the inner liner must be removed and replaced.

At present, it is often necessary to remove the entire engine, or a substantial section of it, during augmentor liner service. Once the engine or engine section is out of the aircraft, the fasteners holding the liner together can be accessed and the damaged liner replaced if necessary. Removing the engine is a timely and costly endeavour, however. A liner that does not require engine or engine section removal during liner service would be advantageous.

According to the present invention, a liner is provided comprising an outer wall, an inner wall, a plurality of standoffs disposed between the walls, and a plurality of attachment assemblies for attaching the walls to one another. The outer wall includes a plurality of first apertures. The inner wall includes a plurality of sections, each section having at least one second aperture. Each attachment assembly includes a fastener and an insert. An insert is received within each first aperture and a fastener is received within each insert.

tener is received within each insert.

Preferably, each insert includes means for locking the fastener within the insert and locking the insert within the outer wall.

In a preferred embodiment, the inner wall sections include male and female joints along circumferential edges for joining one another.

In its preferred embodiments, the present invention permits the removal and replacement of individual inner wall sections rather than entire circumferential liner sections. This feature provides several significant advantages over liners presently available. If a portion of an augmentor liner is damaged, for example, the entire circumferential liner must be removed before it can be repaired or replaced. If the engine or engine sections must be removed before the liner can be removed, the labour cost is substantial. The same repair using the present invention liner, on the other hand, is accomplished at a fraction of the cost because only the damaged inner wall sections need be removed and replaced. In addition, the material replacement cost of a circumferential liner is daunting relative to the cost of one or more inner wall sections. A still further advantage is the time required to replace inner wall sections is considerably less than that required to repair conventional liners. Augmented aircraft are generally used for military purposes, where it is a distinct disadvantage to have an aircraft off-line. The preferred embodiments minimize the time required to maintain augmentor liners and thereby minimize aircraft downtime.

A still further advantage is that the inner wall sections are logistically easier to stock and provide than a full circumferential augmentor liner. This provides a distinct maintenance advantage.

A still further advantage is that a liner is provided to which a coating may be more readily adhered. The inner wall sections are less apt to significantly warp due to thermal load because they may expand more readily. Reducing the warpage helps minimize bonding over stress between the coating and the inner wall. Over stress frequently results in coating separation from the inner wall.

Certain preferred embodiments will now be described, by way of example only, with reference to the accompanying drawings, in which:

FIG. 1 is a diagrammatic view of a liner embodying the present invention.

FIGS. 2 and 3 are cross-sectional diagrammatic views of liners embodying the present invention. FIG. 2 is a sectional view of the liner embodiment shown in FIG. 1.

FIG. 4 is a cross-sectional diagrammatic view of the insert.

FIGS. 5 and 6 show the insert received within a tooling fixture.

FIG. 7 shows the insert received within the outer wall.

FIG. 8 shows an enlarged view of one of the attach-

ment assemblies shown in FIGS. 2 and 3.

Referring to FIGS. 1-3, a liner 10 for a gas turbine augmentor is shown. The liner 10 includes an outer wall 12, an inner wall 14, a plurality of standoffs 16 (FIGS. 2 and 3), and a plurality of attachment assemblies 15. The outer wall 12 is cylindrically shaped and includes a plurality of first apertures 18. The inner wall 14 is formed from a plurality of sections 20, each section 20 having at least one second aperture 22. The inner wall sections 20 may assume a variety of shapes including the rectangular shape shown in FIG. 1. In a first embodiment shown in FIG. 2, the circumferential ends 24 of each section include mating male 26 and female 28 joint halves. In a second embodiment shown in FIG. 3, the circumferential ends 24 of the sections 20 are in contact with tapered ribs 30 attached to the outer wall 12. Referring to FIG. 1, in some applications the inner wall 14 may also include leading edge 32 and trailing edge 34 panels. The panels 32, 34 are disposed on each axial end of the inner wall liner sections 20 to provide a desirable transition between the upstream and downstream engine components (not shown).

Referring to FIGS. 2 and 3, each standoff 16 includes one or more sidewalls 36 and a base 38. The base 38 includes an aperture or a slot 40 (see also FIG. 8) for receiving a fastener 42. The height of the sidewalls 36 establishes the distance the inner wall sections 20 and the outer wall 12 are separated. The standoffs 16 are positioned between the inner 14 and outer walls 12 in alignment with the second 22 and first 18 apertures, respectively. A tab 46 may be included in one or more sidewalls 36 that extends out toward the aperture or slot 40.

Referring to FIG. 8, each attachment assembly 15 includes a fastener 42 and an insert 50. The fastener 42 includes a head 52 and a shaft 54. The insert 50 includes a flange 56 and a body 58. The insert flange 56 is shaped to accept a tool (not shown) for torquing purposes. The insert body 58 includes a center bore 62, an outer surface 64, and one or more slots 66 (see FIG. 4) disposed within the end of the body 58 opposite the flange 56.

Referring to FIGS. 4-8, the insert 50 is initially provided having an untapped uniform diameter center bore 62, the slot 66, and threads disposed in the outer surface 64. The insert 50 is subsequently received within a tooling fixture 68 (see FIG. 5), the latter having a threaded aperture 70 with a taper 72 disposed in one end. A tapered thread tap 74 is run through the center bore 62 of the insert 50, cutting threads throughout the bore 62. As the tap 74 proceeds through the bore 62, the slot 66 disposed in the end of the insert 50 allows the insert body 58 to elastically deflect laterally into the fixture aperture taper 72. As a result, the center bore thread diameter "A" (see FIGS. 7 and 8) is greater in the body segment closest to the flange 56 in comparison with the bore thread diameter "B" (see FIGS. 7 and 8) in the body segment adjacent the slot 66. FIG. 7, which shows a cross-

section of the insert 50 received within the outer wall 12, illustrates the difference in thread diameter ("A" vs "B") in an exaggerated manner for sake of clarity.

Referring to FIGS. 2, 3, and 8, during installation of the inner wall sections 20, a fastener 42 is received within the aperture or slot 40 within each standoff 16. In the embodiment using male 26 and female 28 circumferential joint halves, the inner wall section 20 is circumferentially rotated until one of the male 26 or female 28 halves is fully engaged with the mating section of the adjacent inner wall section 20. The inner wall section 20 is then rotated a distance in the opposite direction to allow the opposite circumferential edge 24 to engage the mating half of the other adjacent inner wall section 20.

In both inner wall section embodiments, the first 18 and second 22 apertures within the walls 12, 14 are aligned and the fasteners 42 are engaged with the inserts 50 using a tool 51 extending through the second apertures 22 in the inner wall sections 20. The section of the insert center bore 62 having a smaller thread diameter ("B") creates an interference fit between the fastener 42 and the insert 50, thereby "locking" the fastener 42 within the insert 50. In this context, the term "locking" refers to the fact that the force necessary to overcome the interference fit between the fastener 42 and the insert 50 is sufficient to prevent the fastener 42 from vibrating free. The portion of the insert 50 extending outside of the outer wall 12 includes the slot 66. The slot 66 enables the insert 50 to expand with the receipt of the fastener 42 to a dimension ("C") greater than the diameter ("D") of the first aperture 18 within the outer wall 12. The expanded portion of the insert 50 "locks" the insert 50 within the outer wall 12 so long as the fastener 42 is received therein. In the embodiment using the tapered ribs 30 (FIG. 3), the tapered ribs 30 are attached after the inner wall sections 20 are attached. In either embodiment, if a tab 46 is included in the standoff sidewalls 36, the tab 46 is bent to extend over the head 52 of the fastener 42 as a further precaution against the fastener 42 unintentionally dislodging.

When at a later time it becomes necessary to replace an inner wall section 20, the fasteners 42 are freed from the inserts 50 using the same tool 51 and procedure as described heretofore. In the first embodiment (FIG. 2), the inner wall section 20 is rotated in one direction until one mating joint 26, 28 disconnects, and then rotated in the other direction until the section 20 is free completely. In the second embodiment (FIG. 3), the tapered ribs 30 are removed prior to removing the inner wall sections 20. After the inner wall sections 20 are removed, the inserts 50 can be removed from outer wall, if desired, without accessing the outside of the outer wall. Hence, there is no need to remove the engine or engine section during liner servicing.

Referring to FIGS. 2 and 3, during operation of the engine the duct 76 formed between the inner 14 and outer 12 walls is filled with bleed air at a pressure higher

than that of the core gas passing by the inner wall 14. The pressurized bleed air forces the inner wall 14 radially inward, away from the outer wall 12. The present invention utilizes that inward force in several advantageous ways. First, the inward force biases the inner wall 14 and attached standoffs 16 inwardly, and thereby further biases the fasteners 42 within the inserts 50. The additional bias helps "lock" the fasteners 42 and the inserts 50 together. Second, the inward force pushes the inner wall segments 20 together and thereby increases the hoop strength of the inner wall 14. The hoop strength of the first embodiment (FIG. 2) increases when the male 26 and female joint 28 halves further engage under pressure. The hoop strength of the second embodiment (FIG. 3) increases when the inner wall sections 20 are forced up the taper of the ribs 30. The increased hoop strength helps the inner wall resist buckling, while adding only minimal additional weight to the liner.

It may be seen from the foregoing that the described embodiments provide a liner that may be readily serviced, a liner that enhances the maintenance of coatings applied thereto, and a liner that minimizes the cost of maintenance.

Although this invention has been shown and described with respect to the detailed embodiments thereof, it will be understood by those skilled in the art that various changes in form and detail thereof may be made without departing from the scope of the invention. For example, this liner 10 has been discussed in terms of an augmentor liner, but may alternatively be used elsewhere in the engine. The attachment assemblies 15 described herein as a method of securing the inner wall sections 20 may also be used to attach the tapered ribs 30 of the second embodiment.

#### Claims

1. A liner comprising an outer wall (12), an inner wall (10), a plurality of standoffs (16) disposed between the walls (10,12) and a plurality of attachment assemblies (15) for attaching the walls (10,12) to one another, wherein the outer wall (12) includes a plurality of first apertures (18), said inner wall (10) includes a plurality of sections (20), each section having at least one second aperture (22) and each attachment assembly (15) includes a fastener (42) and an insert (50), each first aperture (18) having an insert (50) received therein and each insert (50) having a fastener (42) received therein.
2. A liner as claimed in claim 1, wherein each of said inserts (50), has a flange (52) and a body (58), said body (58) including a center bore (62) and an outer surface (64);  
wherein each said insert body (58) is received within one of said first apertures (18), and each said fastener (42) is received within the said insert (50) and is in communication with one of said standoffs.
3. A liner according to claim 2, wherein said insert (50) further comprises a slot (66), disposed at an end of said body (58) opposite said flange (52).
4. A liner according to claim 2 or 3, wherein said center bore (62) and said fastener (42) are threaded; and wherein said center bore (62) includes thread for a portion of said center bore (62) that creates an interference fit with said fastener (42).
5. A liner according to claim 3 or 4, wherein said end of the insert body (58) expands to a diameter (C) greater than that of said first aperture (D) when said fastener (42) is substantially received within said insert (50), thereby preventing said insert (50) from dislodging from said outer wall (12).
6. A liner according to any preceding claim, wherein each said standoff (16) comprises:  
a base (38), having means for receiving said fastener (42);  
a sidewall (36), extending between said base (38) and said inner wall section (20); and  
a tab (46), extending out from said sidewall (36) in the direction of said first aperture (18), wherein said tab (46) deflects to allow said fastener (42) to be inserted.
7. A liner according to any preceding claim, wherein said second apertures (22) align with said first apertures (18) such that a tool (51) may be inserted through said second apertures (22) to access said fasteners (42).
8. A liner according to any preceding claim, wherein each inner wall segment (20) further comprises:  
a first edge (26); and  
a second edge (28);  
wherein one of said first and second edges (20,28) includes one half of a mating male and female joint, and the other of said first and second edges includes the other half of said mating male and female joint.
9. A liner according to any of claims 1 to 7, further comprising:  
a plurality of tapered ribs (30), each said rib (30) having a pair of surfaces tapering from a greater end to a lesser end; and  
wherein each said rib (30) is attached to said outer wall (12), wherein said lesser end is in contact with said outer wall (12) and said inner

wall sections (20) contact said tapered surfaces

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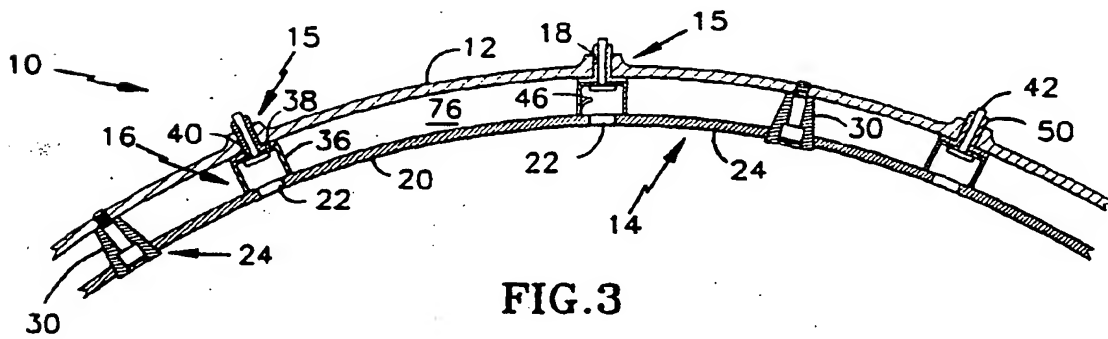
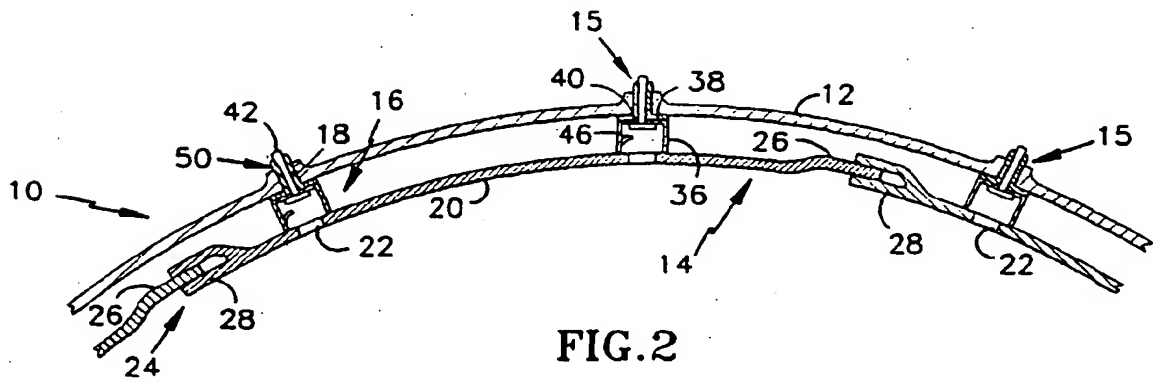
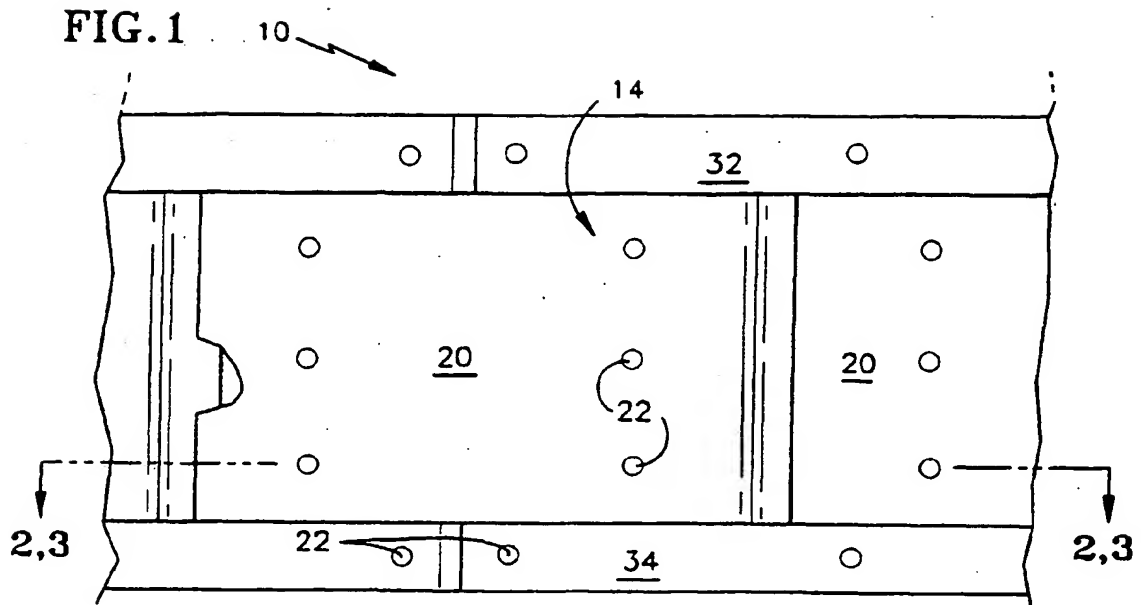


FIG.4

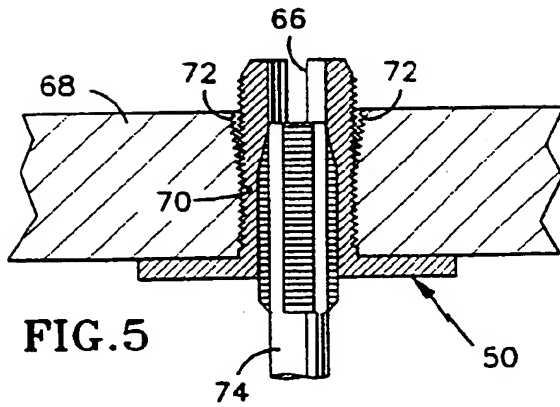
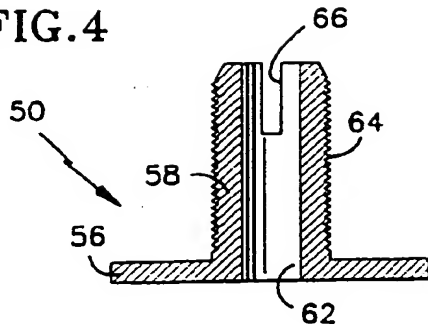


FIG.5

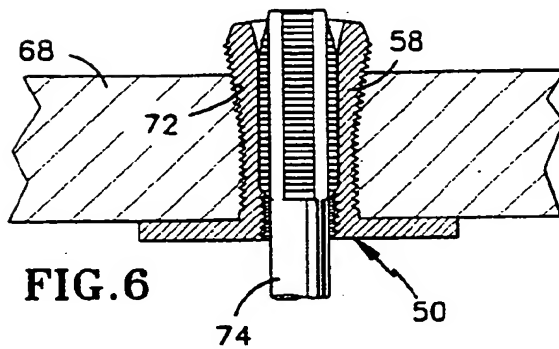


FIG.6

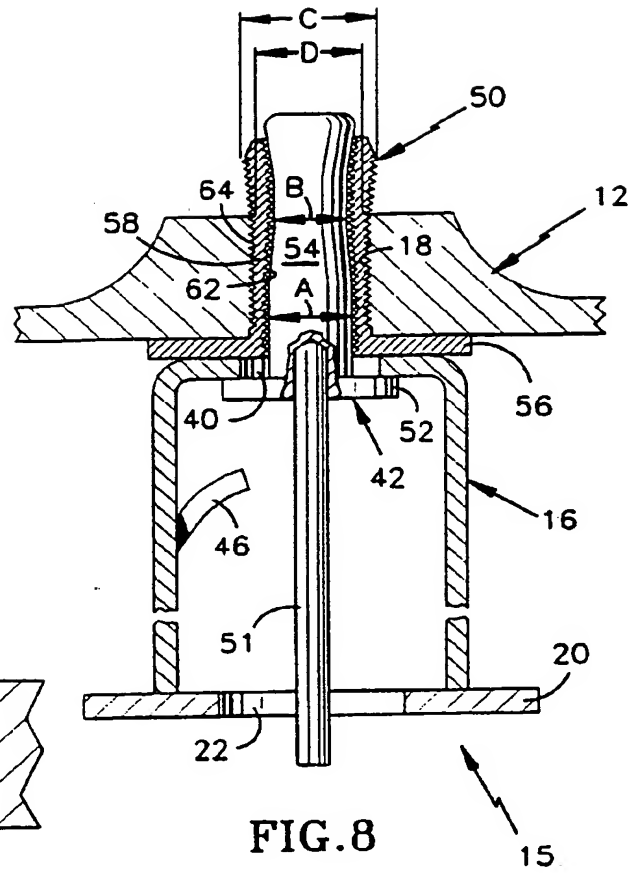


FIG.8

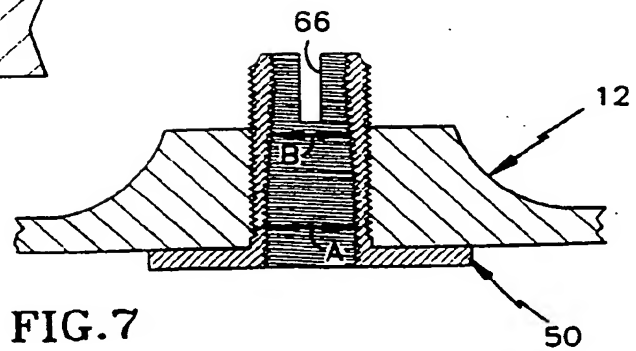
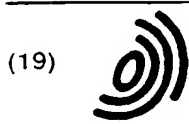


FIG.7





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### (54) Easily replaceable hot conduit liner

(57) A serviceable liner is provided comprising an outer wall (12), an inner wall (10), a plurality of standoffs (16) disposed between the walls (10,12), and a plurality of attachment assemblies (15) for attaching the walls to one another. The outer wall (12) includes a plurality of first apertures (18). The inner wall (10) includes a plurality of sections (20), each section (20) having at least one second aperture (22). Each attachment assembly includes a fastener (42) and an insert (50). An insert (50) is received within each first aperture (18) and a fastener (42) is received within each insert (50).

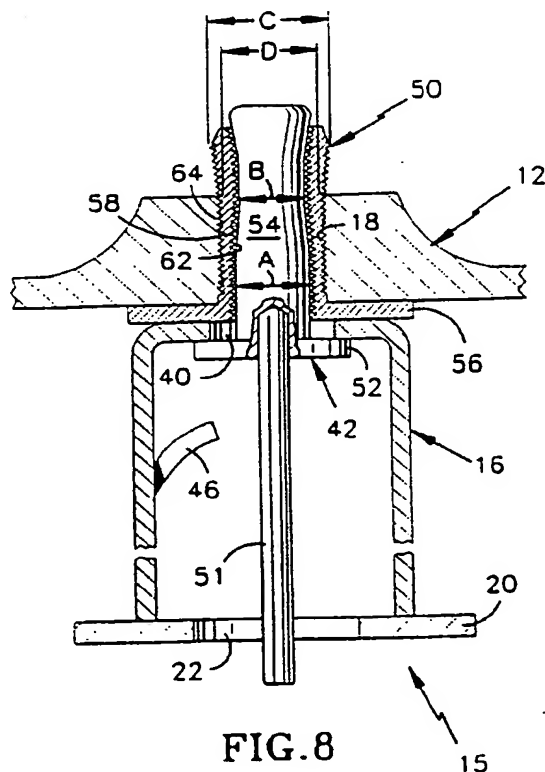


FIG. 8

EP 0 778 408 A3



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## EUROPEAN SEARCH REPORT

Application Number  
EP 96 30 8848

| DOCUMENTS CONSIDERED TO BE RELEVANT  |  |   |  |
|--|--|---|--|
| Category   | Citation of document with indication, where appropriate, of relevant passages  | Relevant to claim   | CLASSIFICATION OF THE APPLICATION (Int.Cl.6) |
| Y  | US 5 083 424 A (BECKER BERNARD)<br>28 January 1992<br>* figure 1 *   | 1-9   | F02K1/82<br>F23R3/00<br>F16B37/12            |
| Y  | US 5 069 034 A (JOURDAIN GERARD E A ET AL)<br>3 December 1991<br>* abstract; figures 1-11 *  | 1-9   |  |
| Y  | DE 36 25 056 A (SIEMENS AG)<br>28 January 1988<br>* abstract; figures 2,3 *  | 1-9   |  |
| Y  | US 5 467 592 A (CARLETTI OLLIVIER)<br>21 November 1995<br>* figure 1 *   | 1-9   |  |
| Y  | FR 2 271 405 A (SNECMA)<br>12 December 1975<br>* figures 1-3 *   | 1-9   |  |
| A  | DE 43 14 160 A (SIEMENS AG)<br>18 November 1993<br>* figures 4.5 *   | 1-9   |  |
| A  | US 5 066 180 A (LANG CHARLES F ET AL)<br>19 November 1991<br>* abstract; figures 1,2 *   | 1-9   | F02K<br>F16B<br>F01D                         |
| A  | US 3 566 947 A (JUKES JOHN A)<br>2 March 1971<br>* the whole document *  | 1-9   |  |
| A  | BERNHARD ROSE: "Der Mensch als Faktor"<br>VDI NACHRICHTEN MAGAZIN, February 1993,<br>pages 19-20, XP002094530<br>* page 19; figure 1 * |   |  |
| The present search report has been drawn up for all claims   |  |   |  |
| Place of search<br><b>THE HAGUE</b>  |  | Date of completion of the search<br><b>24 February 1999</b> | Examiner<br><b>Iverus, D</b>                 |
| <p><b>CATEGORY OF CITED DOCUMENTS</b></p> <p>X : particularly relevant if taken alone<br/>Y : particularly relevant if combined with another document of the same category<br/>A : technological background<br/>O : non-written disclosure<br/>P : intermediate document</p> <p>T : theory or principle underlying the invention<br/>E : earlier patent document, but published on, or after the filing date<br/>C : document cited in the application<br/>L : document cited for other reasons<br/>&amp; : member of the same patent family, corresponding document</p> |  |   |  |

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24-02-1999

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date |
|---|---------------------|----------------------------|---------------------|
| US 5083424 A                              | 28-01-1992          | WO 8912789 A               | 28-12-1989          |
|   |                     | DE 58908665 D              | 05-01-1995          |
|   |                     | EP 0419487 A               | 03-04-1991          |
|   |                     | IN 171210 A                | 15-08-1992          |
|   |                     | JP 3504999 T               | 31-10-1991          |
| US 5069034 A                              | 03-12-1991          | FR 2646880 A               | 16-11-1990          |
|   |                     | EP 0397566 A               | 14-11-1990          |
|   |                     | JP 1880431 C               | 21-10-1994          |
|   |                     | JP 3064629 A               | 20-03-1991          |
|   |                     | JP 6005042 B               | 19-01-1994          |
| DE 3625056 A                              | 28-01-1988          | DE 3645335 C               | 22-05-1997          |
| US 5467592 A                              | 21-11-1995          | FR 2708086 A               | 27-01-1995          |
|   |                     | GB 2279411 A,B             | 04-01-1995          |
| FR 2271405 A                              | 12-12-1975          | NONE                       |                     |
| DE 4314160 A                              | 18-11-1993          | NONE                       |                     |
| US 5066180 A                              | 19-11-1991          | NONE                       |                     |
| US 3566947 A                              | 02-03-1971          | NONE                       |                     |

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